Classroom VIDEO

Teacher's Notes

CHEMISTRY OF THE ENVIRONMENT

Water, Air, Case Study-PNG goldmine

Duration: 34 mins

Years: 11-12

SUMMARY OF THE PROGRAM

00 50 DISSOLVED OXYGEN- DO

When we heat water, before it boils, we can see the oxygen and nitrogen coming out of solution.

Depending on the species, fish require from 2 to 9 parts per million of oxygen in their water. If a stream has less than 1 part per million it will not support life.

Factories and power stations are not permitted to warm rivers, so they cool in cooling towers, ponds or canals.

Plants growing underwater produce oxygen. Oxygen is artificially added to fish tanks or sewage or organic waste to help in decomposition. The amount of oxygen needed to do this is called the Biological Oxygen Demand or BOD.

DO is measured as mg/L. In the test Mn^{2+} is oxidised to Mn^{4+}.

Sewage treatment supplies the oxygen and speeds up the process.

01 20 TURBIDITY

If there is too much mud in a river it will clog the gills of fish. Turbidity means light will not reach very far into water. Plants can't live in water without enough light.

05 30 CALCIUM AND MAGNESIUM

Although we mention only limestone which is calcium carbonate, the same is also true for dolemite which is calcium magnesium carbonate or gypsum.

In limestone country, C02 from rotting vegetation makes the water acid enough to dissolve the limestone.

When the water is heated, or depressurised or agitated the C02 will escape and the limestone will precipitate out of solution. In nature this is the way decorations in limestone caves are formed. In a hot water jug this means a scale. As the water is heated the C02 is driven off, and the calcium carbonate comes out of solution.

If soap is used in hard water, the calcium combines with the stearate ions in the soap to form an insoluble calcium stearate. This is seen as scum. Phosphates are added to detergent to prevent calcium stearate scum forming.

06 60 NITROGEN AND PHOSPHOROUS

Nitrogen and phosphorus are nutrients. This means that if they are in water plants will grow well. The problem comes when the plants die. They rot and aerobic microorganisms use up all the oxygen in the water. This will kill the fish and other water life needing oxygen.This process is known as eutrofication.

Nitrogen mainly comes from fertilizers in the form of nitrites, nitrates, ammonium, or ammonia. Phosphates come from fertilizer or sewage. Sewage has phosphate both from detergents and human waste. In sewage treatment nutrients are removed by alternating the aerobic and anaerobic digestion. (See our video "Sewage Treatment")

NB: Detergents do not have stearate.

08 45 SODIUM,POTASSIUM, CHLORIDE

Salt is needed by plants, however an excess will mean the plant is unable to take up water. Salt will concentrate if the evaporation rate is higher than the rainfall.

Salt inland comes from salt spray from the ocean. If the evaporation rate is higher than the rainfall it is trapped and salinity will increase.

09 30 THE ATMOSPHERE

All of the earth's water and atmosphere were formed in ancient times, from rocks underneath the earth's surface. Carbon dioxide is driven off carbonates by heat.

Various theories on the ancient atmosphere suggest that lightning combined the gases and water vapour to produce amino acids, the chemicals necessary for life. So life evolved underwater, where it was protected. The seaweeds converted C02 to oxygen. In the upper atmosphere the ultraviolet converted oxygen to ozone. This filtered out most of the damaging UV rays, allowing life to grow on land.

1 1 00 CARBON DIOXIDE

Carbon dioxide, water vapour, and methane are greenhouse gases. In the ocean carbon dioxide dissolves in the water and plants use it in the normal hotosynthesis process. Also some is used by shellfish in making their shells. As the carbon dioxide is removed the equilibrium shifts and more carbon dioxide can dissolve in the water.

One of the most promising schemes for solving the greenhouse problem relies on the observation that most of the microscopic plants growing near the surface of the water are low in iron. The idea is that if a few tanker loads per year of iron were added to the surface the excess carbon dioxide would be used by the plants.

A standing healthy forest will have growing trees and dying trees. The growing will use the C02 provided by the decaying.
After volcanoes, the largest natural source Of C02 is fungi and termites.

We can collect methane from buried waste and use it to generate power.

14 10 SULFUR

The sulfur dioxide produced when the sulphides in coal, oil, or mineral ore is burnt.

2PbS + 302 2PbO + 2S02
CU2S + 02 2Cu + S02

The sulfur dioxide produced oxidises to sulfur trioxide in the atmosphere. This then combines with water to form sulphuric acid, it falls out as acid rain or acid fog. The infamous London pea soup smog was a combination of smoke and fog. Sulphuric acid drops collected on particles of soot.

Soot can be removed at power stations by electrostatic precipitation

16 00 PHOTOCHEMICAL SMOG

Photochemical smog is caused by the sun cooking hydrocarbons and nitrogen oxides together to form a new set of poisonous compounds.

N2 + 02 - 2NO
NO +1/2O2 - NO2

Nitrogen oxides are NO2 and NO. They are formed by heating N2 and 02 at high temperature. This occurs in a high temperature flame such as a power station or a car

engine. The hotter the engine the more Nitrogen oxides are produced. Lower combustion temperature means more hydrocarbon escaping due to incomplete combustion.

Catalytic converters in the exhaust system oxidise the hydrocarbons and reduce nitrogen oddes to nitrogen and water. Lead in fuel will poison the catalyst and pollute the exhaust.

To cut photochemical smog fumes from the fuel tank need to be collected when a tank is filled.

In the older nitric acid plants some NO2 escapes. This can be neutralised by adding ammonia to produce nitrogen and water. However modem plants are designed to be more efficient and not release NO2 in the firstplace. Doing it right in the first place is far better than fixups.

UVA 400-320 nm *light tanning vitamin D formation*
UVB 320-280 nm *deep tanning*
UVC 280-200 nm *sunburn*
cancer

19 00 OZONE

At ground level ozone is poisonous and unwanted. It is very poisonous to plants.
We describe UV as A, B or C depending on its energy range. C is the highest. UV B and C are dangerous to humans.
High up in the atmosphere, UV C strikes an oxygen molecule breaking it down to atoms, which then combine with oxygen molecules to produce ozone.

Ozone is broken apart again when it is struck by UV B. In this way the energy of the ultra violet B and C is absorbed and does not reach the surface. But this cycle is broken by chlorine. The chlorine free radical comes from the decomposition of chloro fluoro carbons or CFC as they too are broken down by ultra violet.

Cl + 03 - CIO + 02

The free chlorine radical reacts with the ozone, converting it back to oxygen. But then the CIO is broken down to release the chlorine radical again.

This one chlorine can cause the breakdown of over 1,000 ozone molecules.

21 00 CASE STUDY: PORGERA GOLD MINE

Porgera is in the rugged highlands of PNG. The gold ore body is one of the richest in the world. However it had to be rich to pay the enormous expenses involved in developing a mine in this part of the world.

Before they could build the mine they needed to carry out a lot of projects simultaneously. The land ownership had to be settled so the right people would receive compensation. The relocation agreement had to be negotiated and agreed by everyone. This took years.
The metallurgists had to find a way of removing the very fine gold locked up in the crystals of pyrite (iron sulphide). The mining engineers had to design the optimum design for a mine. Roads had to be built in very steep terrain. Local businesses had to be set up so the local people would be able to participate in the success of the mine.

A source of power was needed. The most likely was hydro and different sites were investigated and rivers measured over many years. They eventually settled on electricity generated from a recent gas discovery nearby.
One of the projects was to investigate the environmental impact of the mining. The main concern was the heavy metals in the ore.

Before mining scientists measured the heavy metals naturally occurring in the streams downstream.
They measured the heavy metals in the water, the

sediments, and in some indicator species of animals and plants. They also measured the heavy metals in humans. They found the more fish people ate from the river, the more heavy metals they had in their systems. In Lake Murray however, they found the worlds highest naturally occurring mercury levels in the people. They measured the water, and the sediment and found them to be very low. They tested to see if the sediment came from the Strickland river that came from the mine. Although the river did sometimes overflow into the lake, geochemical measurements showed that none of the Strickland sediments deposited in the lake. They were flushed out by other rivers feeding into the lake. The source of the mercury is a puzzle.

The problem of the tailings was a difficult one. The country was too steep and unstable to build a large dam to store the tailings. The tailings would add 3% to the sediment in the river already in it's natural state. The government decide there was no other alternative so permission was granted. It was granted on condition that the waste would not harm anyone downstream.

The sulphur from the pyrite was oxidised directly with oxygen under pressure to sulphuric acid. This was later partly neutralised by the calcium carbonate in the tailings of another part of the process.

The tailings are reacted with sodium sulphide to form HgS, one of the most insoluble substances known.

When lime is added the other heavy metals not already reacted will form insoluble oxides. In this form they are not bio-available.

The lime also adjusts the pH to 8, which is the same as the river.

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EXERCISES

1. Devise a simple way of measuring the amount of dissolved air in water at different temperatures.

2. How does oxygen become dissolved in water?

3. How is it removed in nature?

4. Why is industry not permitted to return water to a river after it has been used for cooling their processes.

5. Why do food processing factories need to add oxygen to their waste stream before it is released to the environment? What happens to the river if they do not?

6. What is BOD?

7. How would you set about measuring turbidity?

8. What would cause turbidity?

9. What is wrong with high turbidity?

10. Find out how phosphates reduce the hardness of water.

11. Apart from phosphates, how else could hardness be reduced?

12. What is wrong with adding nutrients to water?

13. How would you reduce the nutrients in water?

14. Where does Salt come from? Draw up a flow chart from source to the environment.

15. If methane is about as effective as carbon dioxide as a greenhouse gas, is it worth while to burn methane produced by rotting waste or sewage.

16. Does a forest produce, oxygen, carbon dioxide, nothing?

17. Work out what role limestone plays in greenhouse.

18. Work out how much $CO2$ is produced in the production of lime and cement.

19. What is the environmental impact of railway sleepers be made of wood, concrete, or steel, or aluminium?

20. List the C02 sources and sinks. How could we intervene?

21. How could you explain the production of H2S04 from the burning of sulphur?

22. Research ways of reducing sulphur dioxide emissions from a coal or oil burning power station?

23. How is photochemical smog produced?

24. How can it be reduced?

25. Balance the following equation.

$$NO2 + NH4 - N2 + H20$$

26. What role does ozone play in protecting us from UV radiation?